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THE TUNA/PORPOISE PROBLEM: DEDICATED VESSEL RESEARCH PROGRAM

Summary of Research Results from the
Fourth Cruise of the Dedicated Vessel
12 September to 31 October 1978

IV

by

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May, 1979

Southwest Fisheries Center
Administrative Report No. LJ-79-14

ABSTRACT

The tuna industry and the Federal Government sponsored the tuna seiner M/V Queen Mary during 1978 as a research platform for studies related to the tuna/porpoise problem. Between September 12 and October 31, 1978, the Queen Mary carried the Porpoise School Impoundment System (PSIS) to the eastern tropical Pacific to conduct porpoise stock assessment research.

The primary objectives of the cruise were to examine school structure, to evaluate feasibility of further mark-recapture studies, and to commence the study of aging by tetracycline marking. Other research efforts on stress and disease factors, comparative feeding habits, mortality reduction technology, behavior, and miscellaneous biological sampling were secondary efforts.

Eighteen sets were made during the cruise: one waterhaul and 17 porpoise sets. Of the porpoise sets, nine utilized the PSIS. The eight remaining sets were used to study purse seine gear dynamics.

Eight hundred seventy-two porpoise were aged and sexed; 656 were tagged of which tetracycline was injected into 331. The number of tags placed per set averaged 73; and the tagging time per animal including capturing and handling averaged 3.5 minutes. This tagging work suggests the operational limits of large-scale tagging in the PSIS with present techniques. School movements were followed by making repeated sets on radio-tagged porpoise. No conclusions are drawn regarding the pattern of movement, but the relative ease with which pelagic porpoise can be radio tracked was demonstrated again. Twenty-two tagged porpoise were recaptured in six sets, suggesting mixing between schools.

Nine porpoise were killed during gear sets, and 36 were killed in PSIS sets. Thirty-eight of the killed animals were recovered and necropsied.

CONTENTS

	<u>Page</u>
I. INTRODUCTION	1
II. VESSEL AND EQUIPMENT	2
III. OBJECTIVES	2
IV. METHODS AND MATERIALS	5
V. RESULTS AND DISCUSSION	9
VI. PORPOISE MORTALITY	39
VII. DISCUSSION AND CONCLUSIONS	39
VIII. SUBMITTAL	42
IX. APPROVAL	42
Appendix A - Tagging methods and tetracycline injections . .	A-1
Appendix B - Radio tracking equipment	B-1

FIGURES

	<u>Page</u>
1 Cruise track, Dedicated Vessel, Cruise V	3
2 Track line of reset sequence #1	18
3 Track line of reset sequence #3	22
4 Net movement and direction of porpoise recaptured that had been tagged in Set 7	24
5 Net movement and direction of porpoise recaptured that had been tagged in Set 8. Net movement and direction tagged of porpoise recaptured in Sets 9 and 11	25
6 Net movement and direction of porpoise recaptured that had been tagged in Set 11. Net movement and direction of tagged porpoise recaptured in Set 12	26
7 Net movement and direction of porpoise recaptured that had been tagged in Set 12. Net movement and direction of tagged porpoise recaptured in Set 13	27
8 Net movement and direction of porpoise recaptured that had been tagged in Set 13	28
9 Net movement and direction of tagged porpoise recaptured in Set 14	29
10. Net movement and direction of tagged porpoise recaptured in Set 15	30
11 Frequency of partial school captures	32
A-1 Tags used in reset sequence	A-2

TABLES

	<u>Page</u>
1 Summary of set statistics	9
2 Individual set statistics	10
3 Color phase and sex composition of porpoise examined through the PSIS	11
4 Frequency of color-phase by sex of porpoise examined in the PSIS	12
5 A comparison of the number of porpoise chased (by species), with the number aged and sexed	13
6 A comparison of the estimates of the school size captured with the number examined through the PSIS	14
7 Summary of tagging operations	16
8 Radio tracking sequence #1	17
9 Radio tracking sequence #2	19
10 Radio tracking sequence #3	20
11 Summary of tag recaptures	23
12 Summary of reset and recapture data in the PSIS	32
13 Summary of data of porpoise chased but not set on	35
14 Net measurements from port rail amidship to 1/4 net, 1/2 net and backdown apex at specified times during the set	38
15 Causes of porpoise death during PSIS sets	40
16 Causes of porpoise death during gear sets	40

I. INTRODUCTION

Thousands of oceanic porpoise (Stenella spp. and Delphinus sp.) are incidentally killed or seriously injured each year during the course of purse seining for yellowfin tuna (Thunnus albacares) in the Eastern Tropical Pacific (ETP). During the period 1972-1977, the United States purse seine fleet reduced its kill of porpoise by 87.4 percent (from an estimated 309,000 to an estimated 27,000). However, a goal of the Marine Mammal Protection Act of 1972 is to reduce the incidental kill and the serious injury rate to insignificant levels approaching zero. Numerous fishing trips and research cruises since 1972 have contributed to the development of methods for reducing this incidental mortality by a significant amount; however, no single vessel has been designated to study and research this problem exclusively.

During all previous research cruises aboard tuna purse seiners, the research was secondary to the capture of tuna because the incentive to the seiners to carry researchers was the opportunity to capture a special allocation of tuna within an otherwise closed area.

For a number of years, it has been recognized that a vessel should be dedicated for tuna/porpoise research free of fishing pressures. In 1977, the United States Tuna Foundation agreed to charter a tuna purse seiner exclusively for tuna/porpoise investigations during 1978.

The Dedicated Vessel Program is a cooperative tuna/porpoise research program under the joint direction of the Marine Mammal Commission (MMC), the National Marine Fisheries Service (NMFS), and the United States Tuna Foundation (USTF). The USTF chartered a commercial tuna seiner, the M/V Queen Mary, to be used as a platform for that research. NMFS, USTF, MMC, and the National Science Foundation (NSF) provided research funds and support. Proposals for relevant research were accepted from all interested persons and organizations.

The overall research plan provided for five cruises of 50 days each. The goals were to: (1) develop and refine fishing gear or techniques to further reduce the incidental mortality rate and (2) provide demographic and biological data needed to better assess the status of the impacted porpoise stocks.

This report summarizes the research activities from Cruise IV. The research funds were provided by the NMFS and the USTF. Dr. Joseph Powers, NMFS, was the cruise leader. Other scientific personnel were: Mr. Richard W. Butler, NMFS; Mr. Thomas M. Duffy, NMFS; Mr. John R. Henderson, NMFS; Mr. Rodney McLain, a contractor to LMR; and Mr. William A. Walker, a contractor to NMFS.

The scientific personnel would like to thank Captain Ralph F. Silva, Jr., and the crew of the Queen Mary for their assistance and total cooperation during Cruise IV.

The Queen Mary departed from San Diego on 12 September 1978 and returned on 31 October 1978, a 50-day trip. The area of research operations was in the Eastern Tropical Pacific (ETP) within the Inter-American Tropical Tuna Commission Regulatory Area (CYRA). The cruise track is shown in Figure 1.

II. VESSEL AND EQUIPMENT

Specifications of the M/V Queen Mary and the Porpoise School Impoundment System (PSIS) are described in detail in the research report from Cruise II of the Dedicated Vessel Program.^{1/} The disc tags, tagging, and tetracycline injection equipment are described in Appendix A, and the radio tracking equipment is described in Appendix B. A 19-foot aluminum workboat with a 115-hp Mercury outboard engine served as the PSIS support boat.

III. OBJECTIVES

The general cruise objective was to conduct porpoise stock assessment research. Ancillary objectives were developed to take advantage of all research opportunities.

A. Porpoise Stock Assessment

The objectives were to:

1. Determine the age and sex structure of porpoise schools captured;
2. Compare actual counts of porpoise schools captured, or portions of schools, with the visual estimates of school size;
3. Tag porpoise to provide information to:
 - a. Evaluate the operational feasibility of tagging large numbers of wild porpoise using the PSIS;
 - b. Estimate the magnitude of short-term tag shedding rates and associated mortality;
 - c. Estimate rates of movement of animals among schools over a short period of time; and

^{1/} Coe, J.M., Jennings, J.G., Peters, C.B., and DeBeer, J. Research Related to the Tuna-Porpoise Problem: Summary of Research Results from the Second Cruise of the Dedicated Vessel, 17 April to 5 June. Southwest Fisheries Center Administrative Report LJ-79-6.

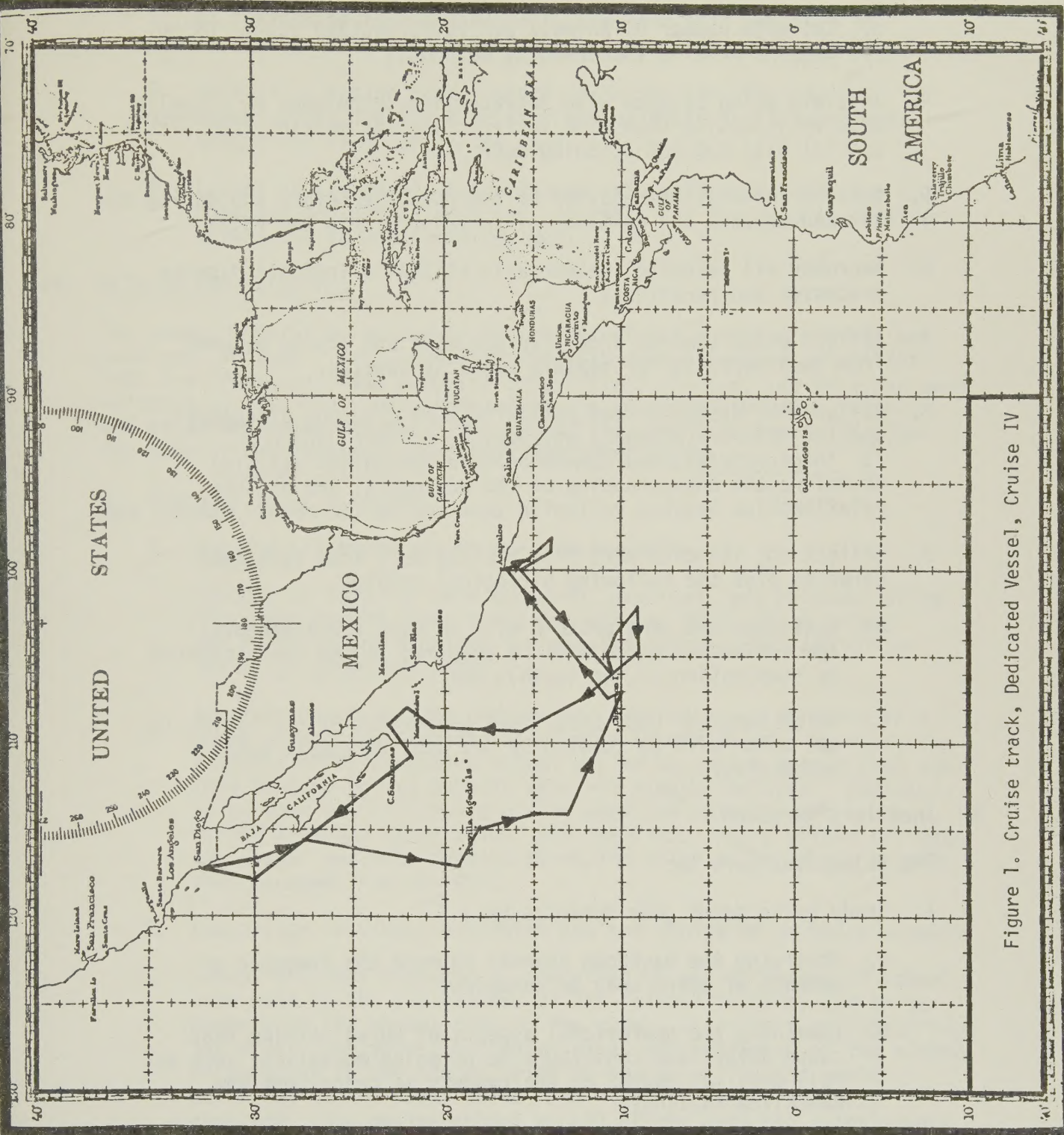


Figure 1. Cruise track, Dedicated Vessel, Cruise IV

- d. Estimate number of animals per radio-tracked school using tagging results (Seber-Jolly methods);
4. Initiate aging studies with tetracycline techniques on Stenella spp. by injecting them with tetracycline and marking them with a special disc tag and notching code;
5. Observe the evasive behavior of the porpoise before and during the set and observe the behavior of porpoise within the PSIS;
6. Necropsy all porpoise incidentally killed to indicate disease processes and parasites;
7. Collect blood samples from live porpoise and tissue samples from dead porpoise for capture myopathy studies;
8. Collect the stomachs from yellowfin tuna (Thunnus albacares), spotted porpoise (Stenella attenuata), spinner porpoise (S. longirostris), and common dolphin (Delphinus delphis) to refine the understanding of the ecological and dietary relationships between yellowfin tuna and marine mammal stocks; and
9. Collect the standard NMFS life history data from each dead porpoise plus the following biological samples:
 - a. Eyes (the eye lens protein will be used for biochemical age estimation which will be compared to the age estimated by examination of the teeth); and
 - b. Melon samples (the acoustical properties of the lipids in the melon will be studied by Dr. Usha Varanasi, Seattle University).

B. Ancillary Research

The objectives were to:

1. Study purse seine gear dynamics by:
 - a. Observing the backdown channel to note the presence or absence of stern sway or canopies;
 - b. Examining the operational aspects of purse seining that cause delays and contribute to porpoise mortality, such as roll-ups, net caught on the rudders or propellers, and bunchline fouling;
 - c. Testing various stimuli before and during backdown to identify any that may be useful in affecting the behavior of tuna or porpoise; and

- d. Measuring the distance from the port rail amidship to points on the corkline at specific times during the set;
2. Maintain a marine mammal watch, maintain the standard NMFS research set log for each set, and maintain the Fishing Mode Record for each day at sea; and
3. Launch an expendable bathythermograph (XBT) probe each day at noon and one during each set and radio XBT data and the weather data daily to radio station WWD.

IV. METHODS AND MATERIALS

The general operating procedure was to search for porpoise schools and make sets on them. Sets involving the PSIS were attempted only before 1400 and if weather, and porpoise school size, species, and behavior were suitable for its use. Other porpoise sets were used for gear research and behavioral observations. The methodology and experimental designs for each of the research objectives are given below.

A. Porpoise Stock Assessment

1. Age and sex structure of porpoise schools

Schools of porpoise were captured, examined, and released using the Queen Mary's purse seine net and the PSIS. Each animal was measured and examined for species, stock, sex, and color-phase (S. attenuata only).

An attempt was made to capture and examine every porpoise in a whole school so sampling bias would be minimized. However, the examination of an entire school was an exception rather than the rule because entire schools were not always captured. Additionally, some porpoise would escape when the animals were transferred from the purse seine into the PSIS. Every effort was made to count and note species, stock, and color-phase of the animals that escaped from the PSIS.

2. Comparison of visual estimates and the census of porpoise schools

School size was examined by comparing visual estimates of school size made by the six members of the scientific party and three members of the vessel crew to the counts of animals passed through the PSIS. The visual estimates were (a) estimates of the number of porpoise in the school prior to the set, (b) the number encircled by the purse seine, and (c) the number actually captured. The entire school or all of the captured animals were not always counted through the PSIS; therefore, the comparison of counts with visual estimates was not always direct.

The visual estimates were obtained by simply polling the observers. An attempt was made to obtain each estimate before the next step in the set: e.g., school size prior to the set was to be obtained before encirclement. However, the required duties of the crew and the scientific party precluded this procedure in some instances.

3. Porpoise tagging studies

The disc tags used were international orange or international yellow and had identifying numbers and geometric designs. Orange tags with a "T" design were used to identify those animals injected with tetracycline. Orange tags with square designs, orange tags with a circle, and yellow tags with a square were used for the experiments in school movement. In addition to the tagging, the animals were notched once or twice in the posterior edge of the dorsal fin to identify the set in which each animal was tagged. To avoid the trauma of tagging, neonates and some juveniles were only notched. The specifications for the disc tags and methods of application are described in Appendix A.

As the tags were placed on the animals, the number, color, and geometric design of the tag were recorded with the school structure information. Periodically, the time at which a tag was attached was recorded, so the average time of tagging could be computed. Physical or behavioral abnormalities of the animals were also noted.

Usually, after an animal had been tagged, it was immediately released into the ocean. During Sets 11 and 12, the tagged porpoise were returned to the corral of the PSIS; when all were tagged or time precluded further tagging, all the animals were released in fewer than five minutes so that the captured school was allowed to maintain some cohesion.

School movements were followed by making sequences of repeated sets on radio-tagged porpoise over a period of days. An initial set was made in which as many animals as possible were tagged. Radio-packs were placed on one or two porpoise so the school could be tracked and set upon again. Two resets were made on the target school. The resets were made on an every-other-day basis, leaving one day for tracking between sets. The color and design of the disc tags were alternated between sets.

Recaptured animals were examined for signs of lost tags, poorly fitting tags, and abnormal behavior which might be related to the tags. If the effect of the tag appeared deleterious, the tag was removed.

4. Porpoise aging studies

Each animal injected with tetracycline was marked with an orange "T" disc tag and double notched at the base of the fin. Tagging procedures were identical to the methods used in the tagging study.

Injections were delivered into the left and right dorsal musculature anterior to the dorsal fin, midway between the dorsal fin and the base of the skull. Injections varied from 10 cc to 25 cc of oxy-tetracycline at a concentration of 100 mg/cc. Thus, based on an average body weight of 100 lbs for all size classes of Stenella attenuata (W.F. Perrin, personal communication), dosages varied from 17 mg to 44 mg per kg body weight. The amount administered was, however, based upon the length of the animal. In general, the following criteria were applied:

<u>total length (cm)</u>	<u>cc injected</u>
greater than 205	25
165 - 205	20
145 - 165	15
132 (1 animal only)	10

Thus, the dosage range (mg/kg) presented above represents a maximum variability. Animals were not weighed, and in the absence of length versus weight data, the exact dosage for each individual is unknown.

5. Observations of porpoise behavior

The evasive behavior of offshore spotted porpoise (Stenella attenuata), eastern spinner porpoise (Stenella longirostris), and northern whitebelly porpoise (Delphinus delphis) was observed at every opportunity during the chase and set and within the PSIS.

6. Research on porpoise diseases and parasites

All animals killed and recovered were necropsied, and representative tissues from all organ systems were preserved for histological analysis. Detailed accounts of gross observations on all major organ systems were recorded.

7. Capture myopathy studies

Blood samples (40 ml) were obtained from the fluke veins of live spotted porpoise during PSIS sets on an opportunistic basis. Samples of liver, spleen, heart, kidney, arteries, and adrenal glands were collected from dead porpoise, frozen immediately, and stored at -60°C.

8. Comparative feeding habits

Porpoise stomachs were examined when the animals were necropsied, and the contents were frozen.

9. Biological sampling

The standard NMFS life history form was completed for each dead animal. Eyes and melon samples were collected when the animals were necropsied.

B. Ancillary Research

1. Research to reduce porpoise mortality

The formation and underwater configuration of the backdown channel was observed from a raft whenever possible. When the net became entangled in the propeller, a diver observed and photographed the problem. The reaction of 20-30 spotted porpoise to an underwater flare was tested by lowering the flare from a raft on a 10-foot piece of twine, while the raft was paddled towards the porpoise.

Measurements of the distance from the port rail of the seiner to three specific points of the corkline were made with a Lietz range-finder. The measurements were made at six times during the set: when the stern end of the net arrived at the seiner, when the net was one-half pursed, when the rings were up, when the net was being rolled, when backdown was started, and when backdown was terminated. The points on the corkline (at quarter-net, at half-net and at the backdown area) were marked with buoys.

2. Marine mammal watch and standard cruise data

A marine mammal watch was maintained during the daylight hours. The set logs were completed for each set, and a record of the vessel's activities was kept for each day at sea.

3. Environmental data

An XBT was launched each day at noon and another during each set when possible. XBT and local weather data was sent by radio to WWD when possible.

V. RESULTS AND DISCUSSION

Eighteen sets were made during Cruise IV: one waterhaul to refine procedures for using the PSIS and 17 porpoise sets (Table 1). There were nine PSIS sets and eight gear sets. An estimated 5700 porpoise and 92 tons of tuna were captured.* All the porpoise avoided capture during two sets. Forty-five porpoise were killed: nine during gear sets and 36 during the PSIS sets. A summary of the individual sets is given in Table 2.

Table 1. Summary of set statistics

Set Type	Number of Sets	Estimated Number of Porpoise Chased	Estimated Number of Porpoise Captured	Number of Porpoise Killed	Number of Porpoise Examined	Number of Porpoise Tagged	Tons of Tuna	Kill per Set
PSIS	9	2079	1523	36	872	656	46	4.0
Gear	8	8794	4178	9	-	-	46	1.1
Water Haul	1	-	-	-	-	-	-	-
Total	18	10873	5701	45	872	656	92	2.6

A. Stock Assessment Research

1. Age and sex structure of captured porpoise school

During the nine PSIS sets, 872 porpoise were aged and sexed (Table 3). The school composition data from each PSIS set are

*All estimates of porpoise school size are crew estimates unless otherwise stated.

Table 2. Individual set statistics

Set No.	Date	Latitude	Longitude	Average Crew Est. of Total School			Average Crew Est. of Porp. Captured			Average Crew Est. of Porpoise Evading Set			Tons Yellowfin	Number Spot. Killed	Number Eastern Spinners Killed	Number Delphinus Killed	Total Killed	Set Type
				Spot	Spin	Delph	Spot	Spin	Delph	Spot	Spin	Delph						
1	9/13	27°23'N	115°47'W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Waterhaul-Practice PSIS
2	9/29	15°48'N	99°35'W	218	24	-	73	4	0	145	20	-	2	0	0	0	0	PSIS-Tetracycline Tags
3	9/20	14°54'N	99°02'W	107	46	-	15	30	0	91	16	-	0	0	0	0	0	Gear
4	10/3	16°03'N	100°42'W	113	0	-	52	0	0	61	0	-	1	1	0	0	1	PSIS-Radio Tracking
5	10/5	14°59'N	101°14'W	220	147	-	0	0	0	220	147	-	0	0	0	0	0	Gear
6	10/6	11°19'N	104°18'W	1467	1200	-	639	144	0	826	1056	-	5	0	0	0	0	Gear
7	10/7	11°08'N	105°11'W	131	53	-	122	17	0	8	37	-	8	10	3	0	13	PSIS-Radio Tracking
8	10/8	10°22'N	105°37'W	181	59	-	149	1	0	33	57	-	7	5	0	0	5	PSIS-Tetracycline Tags
9	10/9	10°25'N	105°55'W	402	498	-	405	312	0	0	183	-	10	0	1	0	1	Gear
10	10/9	10°23'N	106°17'W	660	540	-	660	440	0	0	100	-	20	0	2	0	2	Gear
11	10/11	10°39'N	105°31'W	328	163	-	320	97	0	8	67	-	20	6	2	0	8	PSIS-Radio Tracking
12	10/13	10°50'N	104°39'W	79	75	-	70	67	0	8	9	-	1	1	3	0	4	PSIS-Radio Tracking
13	10/15	10°51'N	105°41'W	60	19	-	40	14	0	12	4	-	1	0	1	0	1	PSIS-Tetracycline Tags
14	10/15	10°51'N	105°28'W	880	220	-	880	220	0	0	0	0	10	1	2	0	3	Gear
15	10/23	11°10'N	106°22'W	274	159	-	269	156	0	5	3	-	4	1	3	0	4	PSIS-Tetracycline Tags
16	10/24	13°44'N	108°16'W	143	0	-	72	0	0	71	0	-	2	0	0	0	0	PSIS-Tetracycline Tags
17	10/26	22°16'N	107°52'W	-	-	407	-	-	433	-	-	0	1	0	0	3	3	Gear
18	10/27	22°52'N	108°59'W	2000	0	-	0	0	0	2000	0	-	0	0	0	0	0	Gear
Avg: PSIS Sets (Excluding Water Haul)				170	61	0	130	40	0				5.11	2.67	1.33	0.00	4.00	
Avg: Gear Sets				717	332	51	325	143	54				5.75	0.13	0.63	0.38	1.13	
Avg: All Sets (Excluding Water Haul)				427	188	24	222	88	25				5.41	1.47	1.00	0.18	2.65	

Table 3. Color phase and sex composition of porpoise examined through the PSIS

Offshore Spotted Porpoise			Eastern Spinner Porpoise	
Color-phase	Male	Female	Male	Female
Neonate	4	2	No Color Phases	
Two-tone	31	43		
Speckled	80	72		
Mottled	50	51		
Fused	246	251		
Total	411	419	22	20
%	49.5	50.5	52.4	47.6

given in Table 4. The overall sex ratio of all the porpoise examined of each species was about 50:50. However, there was a considerable variation of the sex ratio in the different schools examined. For example, the percentage of male spotters in a school ranged from 32 to 72 percent and, conversely, of females from 28 to 68 percent.

The color-phase distribution for all spotters was also quite similar between the sexes. More elaborate analyses, using kill data from the tuna boats with observers and school structure data from Cruise II of the Dedicated Vessel, will be done subsequently to assess these distributions in terms of school structure.

An entire school was not examined in any set. However, for several sets, the number of escaping animals was small, so bounds may be placed on the possible age and sex distributions in those schools. The proportions of each color phase by sex varied considerably from one set to the next (Table 4). In several sets, the variation cannot be totally attributable to small sample sizes. The variation may, indeed, be real or a product of some sampling bias, such as escape. An estimated 54 percent of the spotters and 8 percent of the spinners in the schools that were chased were examined (Table 5).

Table 4. Frequency of color phase by sex of porpoise examined in the PSIS ^{1/}

Set No.	Offshore Spotted Dolphins																				Eastern Spinner Dolphins									
	Males										Females										Total									
	Neonate			Two-tone			Speckled			Mottled			Adult			Total Males			Total Females			Total								
	No	%		No	%		No	%		No	%		No	%		No	%		No	%		No	%		No	%				
2	1	1.72	2	3.45	17	29.31	3	5.17	35	60.34	58	54.72	0	0.00	1	2.08	13	27.08	12	25.00	22	45.83	48	45.28	106	3	60.00	2	40.00	5
4	2	8.33	2	8.33	6	25.00	2	8.33	12	50.00	24	38.71	2	5.26	5	13.16	6	15.79	6	15.79	19	50.00	38	61.29	62	-	-	-	-	-
7	0	0.00	7	8.05	16	18.39	15	17.24	49	56.32	87	61.70	0	0.00	9	16.67	8	14.81	7	12.96	30	55.56	54	38.30	141	2	33.33	4	66.67	6
8	0	0.00	9	14.52	10	16.13	7	11.29	36	58.06	62	37.80	0	0.00	14	13.73	11	10.78	6	5.88	71	69.61	102	62.20	164	-	-	-	-	-
11	0	0.00	5	9.62	9	17.31	3	5.77	35	67.31	52	47.27	0	0.00	3	5.17	14	24.14	4	6.90	37	63.79	58	52.73	110	2	50.00	2	50.00	4
12	0	0.00	1	9.09	3	27.27	0	0.00	7	63.64	11	32.35	0	0.00	2	8.70	4	17.39	4	17.39	13	56.52	23	67.65	34	6	40.00	9	60.00	15
13	0	0.00	0	0.00	8	19.51	4	9.76	29	70.73	41	71.93	0	0.00	2	12.50	3	18.75	2	12.50	9	56.25	16	28.07	57	4	80.00	1	20.00	5
15	0	0.00	3	6.98	8	18.60	10	23.26	22	51.16	43	46.24	0	0.00	6	12.00	6	12.00	6	12.00	32	64.00	50	53.76	93	5	71.43	2	28.57	7
16	1	3.03	2	6.06	3	9.09	6	18.18	21	63.64	33	52.38	0	0.00	1	3.33	7	23.33	4	13.33	18	60.00	30	47.62	63	-	-	-	-	-
Total	4	7.97	31	7.54	20	19.46	50	12.17	246	59.85	411	49.52	2	0.48	43	10.26	72	17.18	51	12.17	251	59.90	419	50.48		22	52.38	20	47.62	43

^{1/} Includes animals incidentally killed and examined.

Table 5. A comparison of the number of porpoise chased (by species) with the number aged and sexed

Set Number	Estimate of Number Prior to Chase		Number Aged and Sexed	
	Spotted	Spinner	Spotted	Spinner
2	218	24	106	6
4	113	0	62	-
7	131	53	141	6
8	181	59	164	-
11	328	163	110	4
12	79	75	34	15
13	60	19	57	5
15	274	159	93	7
16	143	-	63	-
TOTAL	1527	552	830	43

2. Comparison of the estimated school size with an actual census

School size estimates were made for all sets by the six members of the scientific party and three crew members. Estimates were made of the size of the entire school chased and the number of porpoise captured. The average number of animals estimated as captured in the purse seine on PSIS sets compared favorably to the PSIS counts when known (Table 6). However, all of these estimates were for relatively small groups of animals. The average count of those sets where PSIS counts were available was not greatly different between the observer estimates and PSIS counts.

Porpoise were tagged in all of the PSIS sets. Since tagging had the highest research priority during Cruise IV, tag placement affected other research goals such as school size estimation. In several cases, the limits of the PSIS and scientific personnel dictated that only a relatively small portion of a school could be counted. In these cases, the number of animals which were captured in the purse seine and escaped from the PSIS during backdown was large.

Table 6. A comparison of the estimates of the school size captured with the number examined through the PSIS

Set No.	Species in School	Average Estimate of School Size	Range of Estimates	Standard Error of Mean	Number of Estimates	PSIS Count	Number of Known PSIS Escapes	Number of Known PSIS Captures	% Difference
2	Spotted/E. Spinners	100	50-200	21	6	111	9	120	+ 16.6
4	Spotted -	57	30-175	13	9	62	6	68	+ 16.2
7	Spotted/E. Spinners	134	35-165	19	8	149 ^d	15-20	164-169	+ 19.5
8	Spotted/E. Spinners	163	80-200	10	8	165 ^d	14	179	+ 8.9
11	Spotted/E. Spinners	431	300-550	16	8	116 ^d	- ^a	-	
12	Spotted/E. Spinners	137	60-250	17	9	49	-	-	
13 ^b	Spotted/E. Spinners	77	55-140	8	8	62 ^d	13	75	- 2.7
15 ^b	Spotted/E. Spinners	425	200-600	34	9	101	-	-	
16	Spotted -	79	60-100	5	9	63	14-19	77-82	0.6
Grand Mean		101.7		16.1				114.7	+ 11.3 ^c

^a Animals escaping from PSIS were too numerous to count.

^b Entire school was captured in the purse seine.

^c Mean for Sets 2, 4, 7, 8, 13, and 16, only. The midpoint of the range of known PSIS captures was used on Sets 7 and 16.

^d These counts do not agree with the sum of the animals by set examined in Table 4 because animals of unknown species or sex escaped.

3. Porpoise tagging studies

Although four sub-topics are listed above under the objectives of tagging studies, only one (the feasibility of tagging large numbers of porpoise using the PSIS) will be discussed in detail in this report. Estimates of short-term tag shedding, estimates of rates of movement among schools, and estimates of the number of animals in the radio-tagged schools will be investigated using the data in this report. However, the detailed analyses will be presented in subsequent publications.

Six hundred fifty-six porpoise were tagged with disc tags during the cruise (Table 7). The number of tags placed per set ranged from 42 to 131 and averaged about 73. Excluding the first tagging set, where the scientific team went through a learning phase in handling the tagging equipment, the average tagging time per animal was between 3.0 and 3.8 minutes and averaged 3.5 minutes overall. This time was not just that required to attach the tag, but also included the associated activities of catching the animals in the PSIS and bringing them to the chutes, handling the animals in the chutes, sexing, measuring, injecting tetracycline, placing radio packs, and replacing equipment, as well as resting periods and time to deal with sharks (watching for them and "neutralizing" them with a bang stick). The time does not include that spent collecting blood samples.

a. School movements and resets

● Reset Sequence #1

The first attempt at radio tracking a porpoise on Cruise IV occurred during Set 4, a PSIS set on 3 October 1978. An adult male (210 cm) and an adult female (173 cm) were each fitted with VHF radio packs. The female, designated as Animal A, was the last animal released from the PSIS at 1644. The male, Animal B, was released earlier when there were about 20 porpoise remaining in the PSIS. They were released at 16°02'N, 100°42'W.

Tracking began at 1740 after the PSIS was retrieved. At that time, the radios on both animals were transmitting well. Each animal appeared briefly on the surface every three or four minutes. By 1855, it was obvious that "A" and "B" were headed in different directions, at which time the decision was made to pursue "A". The signal from "B" was last received at 2132 that evening.

Table 7. Summary of tagging operations

Set No.	Disc ^a Type	Notch ^b Code	Spotted Dolphin Tagged and Released			Eastern Spinner No. of Disc Tags	Total Number of Disc Tags Placed	Tagging Operations	Average Minutes Per Tag Per Chute
			No. of Disc Tags	No. of Notched Only	No. of Radio Tags				
2	OT	DNB	44	0	0	0	44	Disc Plus Tetracycline	4.4
4	YS	SNT	52	7	2	0	52	Disc Plus 1 Radio Tag	3.3 ^c
7	OS	SNM	128	2	1	3	131	Disc Plus 1 Radio Tag	3.6 ^c
8	OT	DNB	131	0	0	0	131	Disc Plus Tetracycline	3.3
11	OS	SNB	101	0	2	0	101	Disc Plus 2 Radio Tags	3.2 ^d
12	YS	DNM	29	1	1	12	41	Disc Plus 1 Radio Tag	3.8 ^c
13	OT	DNB	50	0	0	0	50	Disc Plus Tetracycline	3.4
15	OT	DNB	64	0	0	0	64	Disc Plus Tetracycline ^e	3.7
16	OT	DNB	42	0	0	0	42	Disc Plus Tetracycline ^e	3.0
TOTAL			641	10	6	15	656		

^aDisc tag types were: Orange T (OT), Orange Square (OS), and Yellow Square (YS).

^bNotch codes were: double notch at the base of the dorsal fin (DNB), single notch at the tip of dorsal fin (SNT), single notch base (SNB), single notch mid dorsal (SNM), and double notch mid dorsal (DNM).

^cIncludes time needed to place one radio tag on a spotted porpoise (less than five minutes).

^dIncludes time needed to place a radio tag on each of two spotted porpoise (less than 10 total minutes).

^eBlood sampling also occurred, however, it is not included in times.

Animal "A" was tracked for the remainder of that day and all of the next day (Figure 2). The vessel was stopped short of the animal when the signal strength indicated the animal was within two to three nautical miles. Every effort was made not to "push" the porpoise. With the vessel stopped, the signal was monitored on the automatic direction finder until it weakened to the point where there was a danger of losing the signal. Then, with one engine at idle speed (4-5 knots), the animal was followed. At one point in the day, the animal was seen with a large group of spotters and spinners.

On October 5, the third day, an attempt was made to set on the radio-tagged animal and a school that was associated with it (estimated at 720 spotters and 80 spinners). The school broke up, and the radio-tagged animal was sighted swimming alone. This animal was then abandoned from further tracking at 0910. The total tracking time was 40 hours 26 minutes over a trackline distance of 90.7 nautical miles (Table 8).

The animals in the area close to the coast of Mexico are called "untouchables" and are difficult to catch. This school was pursued for well over an hour and could not be bunched up enough to make a set. Later that afternoon, another set was made on porpoise in the same area; all escaped, so the vessel traveled on to another area (Clipperton Island).

Table 8. Radio tracking sequence #1

Set	Date	Position	Time	Distance in Nautical miles	Comments
4	Oct. 3	16°03'N, 100°42'W	1740	6.3	Animals A&B released
		15°59'N, 100°37'W	1950	4.2	Animals separated
		15°55'N, 100°36'W	2113	9.8	"A" followed
		15°49'N, 100°28'W	2205	11.0	
	Oct. 4	15°39'N, 100°29'W	0250	6.6	
		15°35'N, 100°34'W	0350	3.6	
		15°33'N, 100°37'W	0610	7.8	
		15°30'N, 100°44'W	0720	8.4	
		15°37'N, 100°40'W	1230	9.6	
		15°31.8'N, 100°32.4'W	1735	6.9	
		15°27.5'N, 100°37'W	1900	8.3	
	Oct. 5	15°28.5'N, 100°44.8'W	0630	8.2	
		15°27.6'N, 100°52.8'W	0800	-	Reset attempted, School would not bunch up-abandoned

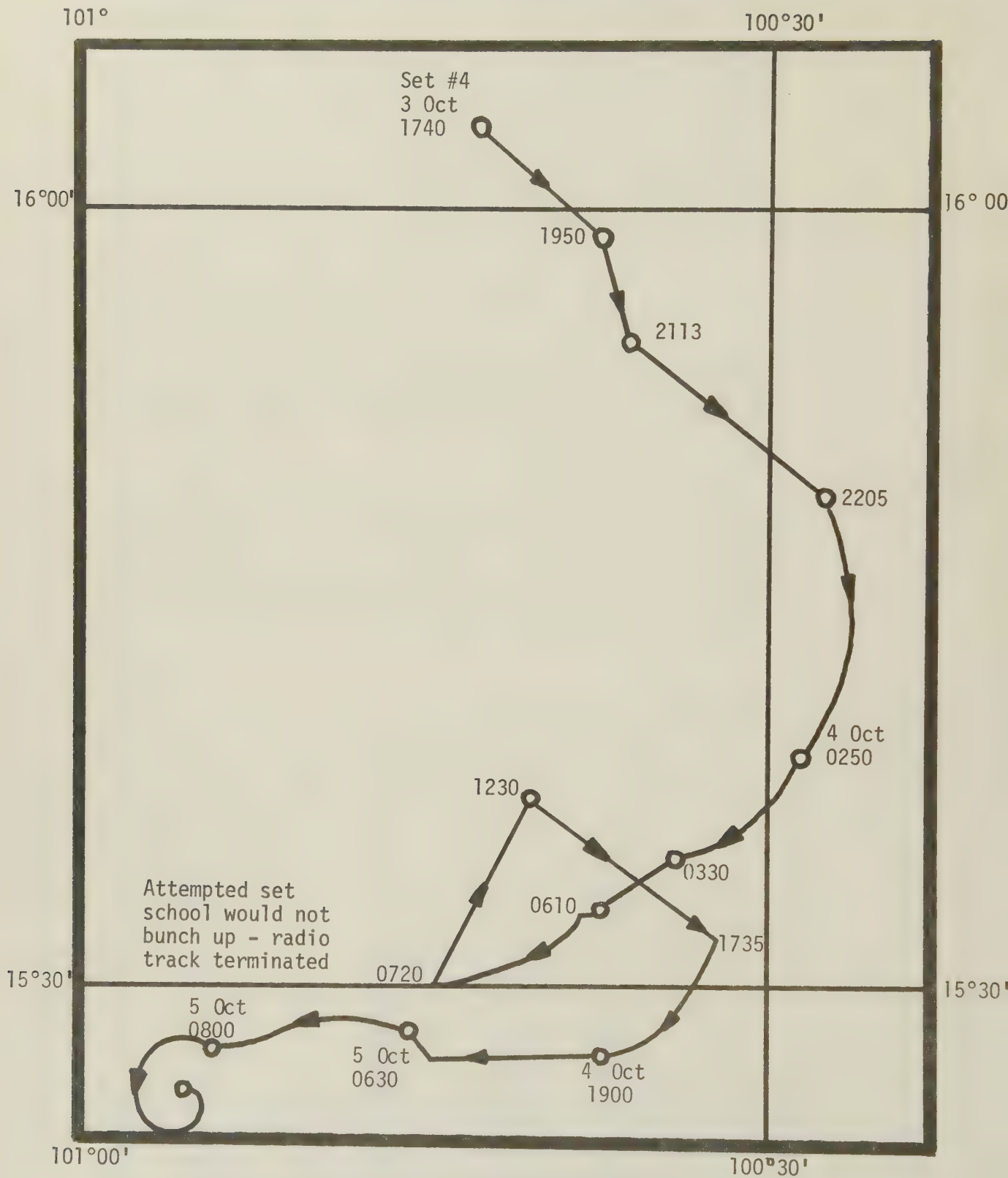


Figure 2. Track line of reset sequence #1

● Reset Sequence #2

The second attempt at radio tracking occurred during Set 7 on 7 October. A 205-cm male spotter was fitted with a VHF radio pack, released at 1656 and tracked for about nine hours until the signal ceased at 0200 (Table 9). The signal returned a constant pulse at 0305, and, at dawn, the radio pack was sighted adrift and retrieved. The plastic saddle had torn loose from the bolt that attached it to the dorsal fin.

Table 9. Radio tracking sequence #2.

Set	Date	Position	Time	Distance in Nautical Miles	Comments
7	Oct. 7	11°08'N, 105°11'W	1656	} 19.1	(VHF) Animal released
	Oct. 8	?	0200		Signal ceased
		10°56'N, 105°22'W	0630		Radio pack picked up floating

● Reset Sequence #3

The third attempt at radio tracking started during Set 11 on 11 October. Two adult male spotters were each fitted with radio packs: one spotter, 185 cm long, carried a VHF radio and the other spotter, 211 cm long, an HF radio. A signal check before the animals were released indicated that both transmitters were functioning; however, the HF signal (channel) was "noisy." After the animals were fitted with radio packs, they were released back into the corral and were observed; both radio packs fitted well. Both animals were released along with 36 others between 1737 and 1742; however, tracking did not begin until 1905 after the PSIS was retrieved.

At that time, the HF beacon could be heard weakly through the interference. Within minutes, the HF signal could not be heard and is believed to have malfunctioned.

The animal carrying the VHF beacon was tracked that night and all the next day (12 October). At 0755, 13 October, Set 12 was made on a school of 150 spotters and spinners accompanying the animal carrying the radio pack (Table 10). One other animal, tagged with a disc tag, was recaptured.

Table 10. Radio tracking sequence #3

Set	Date	Position	Time	Distance in Nautical Miles	Comments
11	Oct. 11	10°39'N, 105°31'W	1905	18.5	Animal released Tracking began
	Oct. 12	10°39'N, 105°11'W	0645	15.3	
		10°46'N, 104°59'W	1125	29.3	
12	Oct. 13	10°50'N, 104°40'W	0630	N/A (chased for set)	Set 12 (0755)
		10°50'N, 104°29'W	1235		New animal released
	Oct. 14	10°41'N, 105°05'W	0610	15.5	
		10°25'N, 105°20'W	1200	16.6	
		10°22'N, 105°36'W	?	25.7	
	Oct. 15	10°46'N, 105°33'W	0730	N/A (chased for set)	
13		10°52'N, 105°42'W	0828	----	

During the set, the radio-equipped animal was transferred into the PSIS. After an examination of the animal's dorsal fin, the radio pack was removed. The skin on the upper portion of the fin appeared to be sloughing off, probably due to reduced circulation caused by applying the pack too tightly. The pinhole through the fin appeared healthy. The condition of the radio pack was fair; however, the potting foam* was water soaked and the lining was compressed. To continue the tracking, a new radio pack was placed on a different adult male spotter (190 cm), and this animal was released with about 20 other spotters at 1120 on 13 October. The animal was tracked for the rest of that day and all the next day. It was recaptured along with 54 other porpoise during Set 13 at 0818 on

*The potting foam was used to achieve both a hydrodynamic design as well as maximize floatation for recovery.

15 October. Tracking had been normal and had continued unaffected through heavy rain squalls. The track is shown in Figure 3. Six animals, disc tagged in the same set as the radio-tagged animal, were also recaptured. That set terminated the reset sequence, so the radio tag was removed and the animal released.

The reset sequence began at 1905 on 11 October at 10°39'N, 105°29'N, and continued until 0730, 15 October at 10°52'N, 105°42'W. The distance covered was about 150 nautical miles.

b. Tag Recaptures

Twenty-two disc-tagged porpoise were recaptured in six sets: four PSIS sets and two gear sets (Table 11). The relationships between each tagging set and recapture set are shown in Figures 4-10.

Eleven animals with disc tags were recaptured and examined during PSIS sets (Table 11), and nine of them were released with the tags in place. Six of the recaptures examined were associated with the two resets in which the searching effort was not random but rather directed by the signal of the radio tag. One additional animal with a disc tag was transferred into the PSIS during a reset (Set 13). It escaped before it could be examined; however, the notch code indicated the animal had been tagged in Set 12.

Recaptures of tagged animals were made in two non-PSIS sets (9 and 14). Although the numbers on the tags could not be read, the set in which the animals had been tagged were determined from the notch code and the condition of the notches.

Two disc tags (OS) which had been on animals for 12 and 15 days, respectively, were removed because of pressure necrosis around the attachment points, somewhat flacid dorsal fins, and "loose" skin and blubber indicating recent weight reduction. In both cases, the tags had been fastened too tightly and were of poor quality, being flat and not convex.

The recapture information from the reset sequence (Table 12) suggests mixing among schools. Sets 11, 12, and 13 constitute the planned reset sequence in which the animals were radio tracked. However, Sets 7, 8, and 15 occurred in the same small geographical area, and recaptures indicate that emigration occurred from these schools to those involved in the initial radio-tracked school. Therefore, these may be considered in the reset sequence in subsequent analyses of school cohesion (inter-school migration).

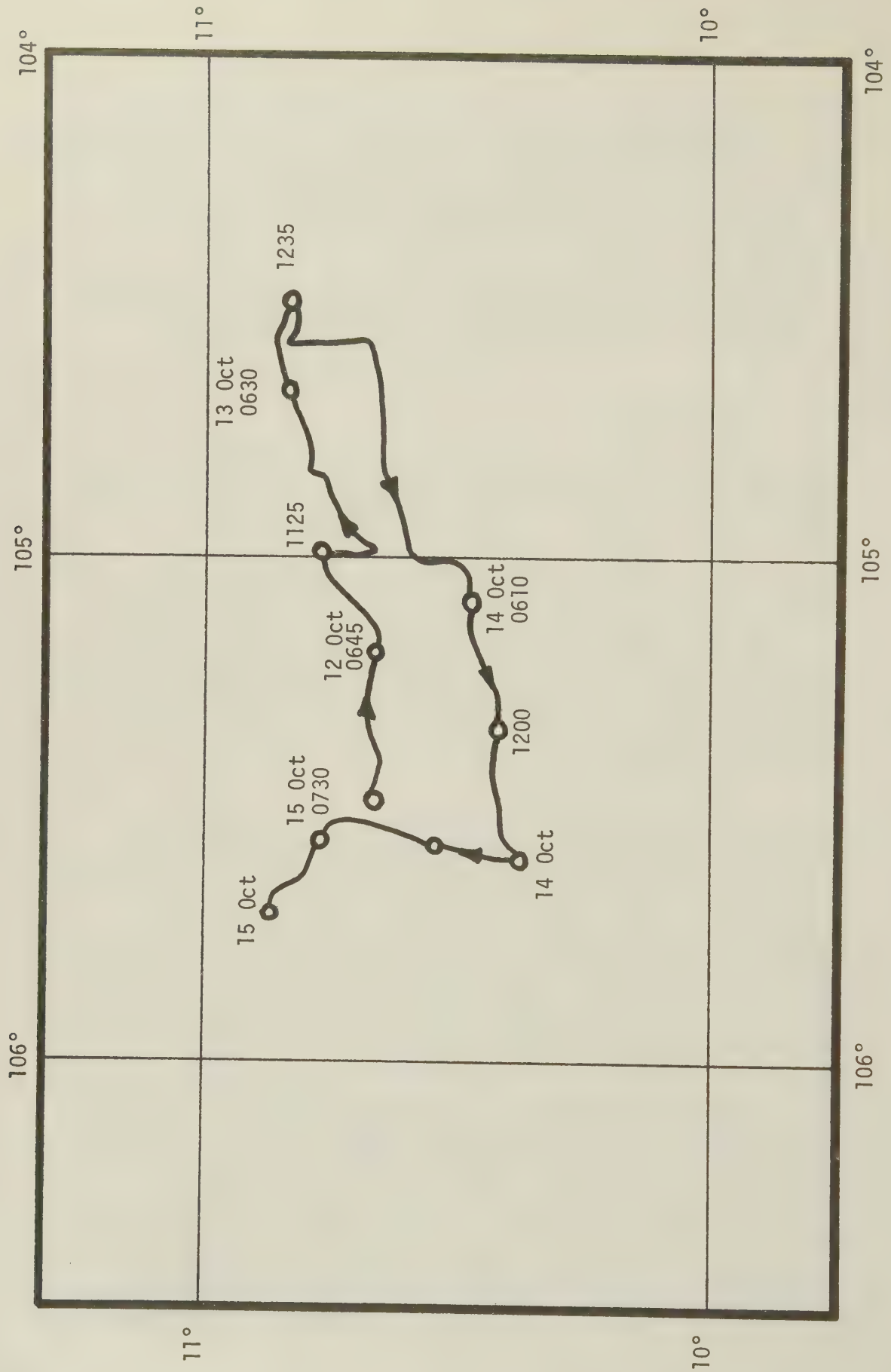


Figure 3. Track line of reset sequence #3

Table 11. Summary of tag recaptures

Set No.	Set Type	Recaptures				
		Set of Placement	Species	Tag Type	Days at Liberty	Comments
9	Gear	8	Spotted	OT	1	Observed in gear set
		8 or ?	Spotted	OT	1	Observed in gear set
11	PSIS	8	Spotted	OT	3	Examined and released
12	PSIS	11	Spotted	Radio	2	Tag removed, animal released
		11	Spotted	OS	2	Examined and released
13	PSIS	12	Spotted	Radio	2	Tag removed, animal released
		12	Spotted	YS	2	Examined and released
		12	Spotted	YS	2	Examined and released
		12	Spotted	YS	2	Examined and released
		12	Spotted	YS	2	Examined and released
		12	Spotted	YS	2	Examined and released
		12	Spotted	YS	2	Examined and released
		12	Spotted	YS	2	Escaped without examination
14	Gear	11	Spotted	OS	4	Observed in gear set
		11	Spotted	OS	4	
		7	Spotted	OS	8	
		12	Spinner	YS	2	
		12	Spinner	YS	2	
		8-13 ^a	Spotted	OT	0-7?	
		8-13 ^a	Spotted	OT	0-7?	
		8-13 ^a	Spotted	OT	0-7?	
15	PSIS	7	Spotted	OS	16	Tag removed, animal released
		11	Spotted	OS	12	Tag removed, animal released
		13	Spotted	OT	8	Examined and released
		13	Spotted	OT	8	Examined and released
Total disc tags recaptured and examined in PSIS = 11						
Total disc tags recaptured in all sets = 22						

^a Could have been Set 8 or 13, probably not Set 2 because it was a completely different area.

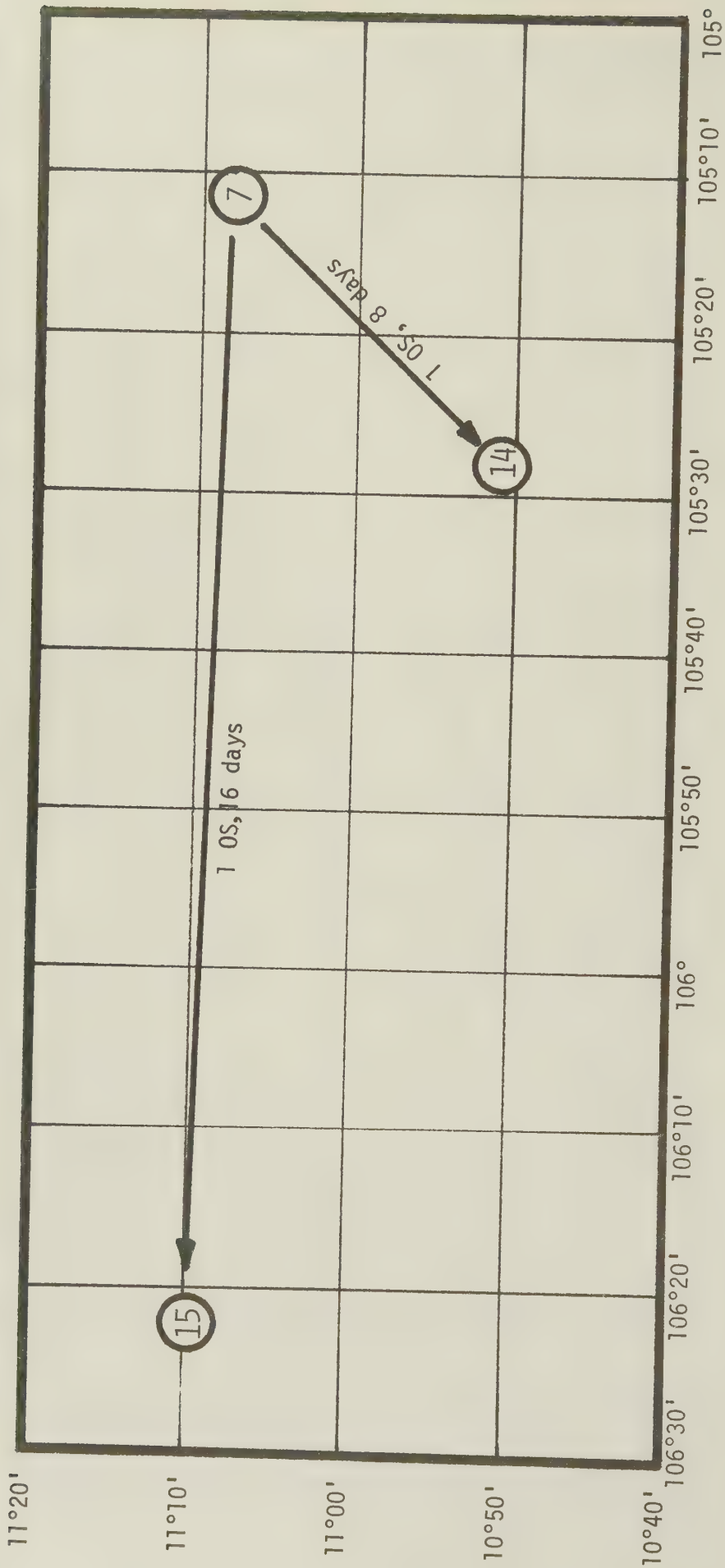


Figure 4. Net movement and direction of porpoise recaptured that had been tagged in Set 7.

○ Set number

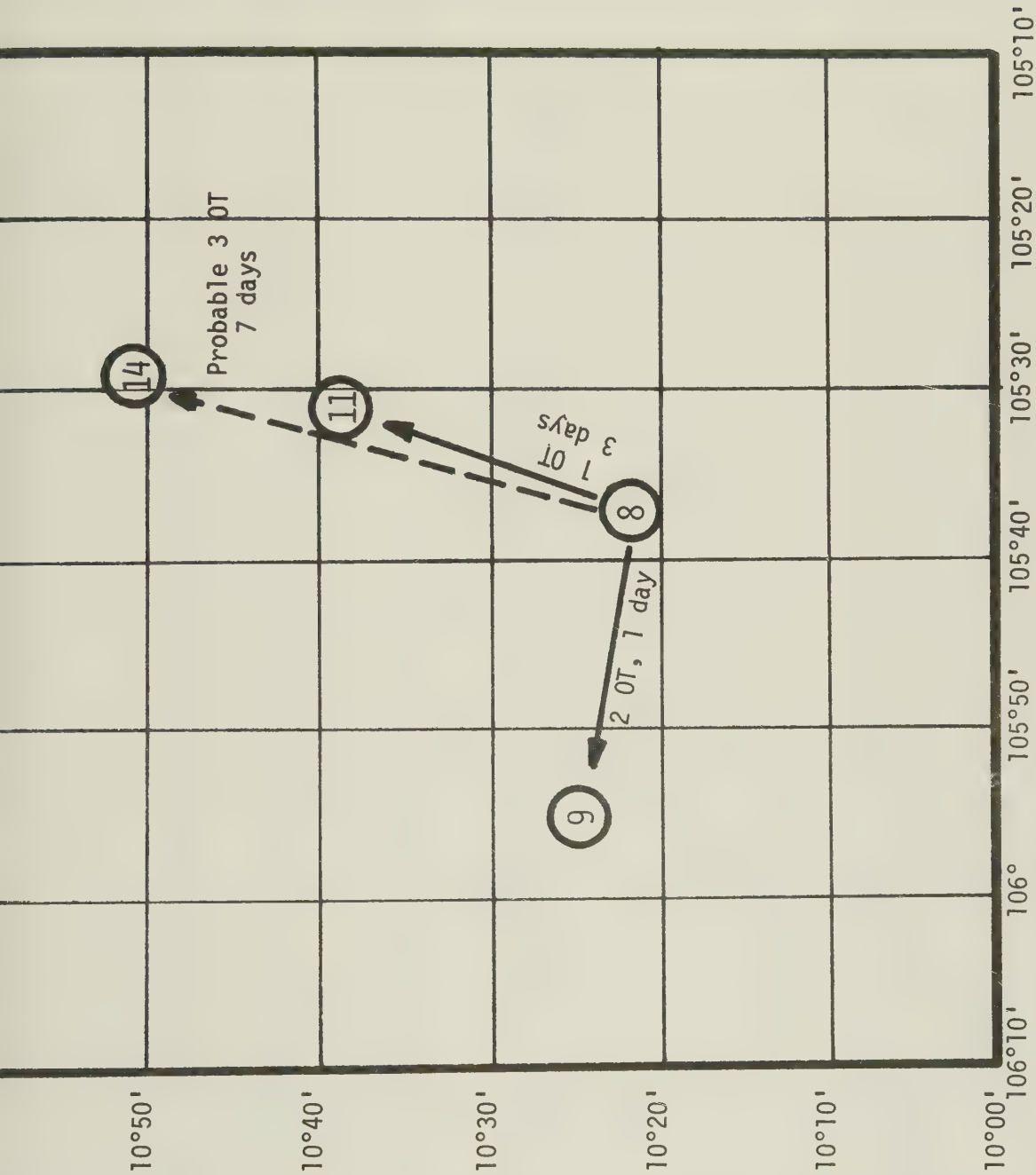


Figure 5. Net movement and direction of porpoise recaptured that had been tagged in Set 8.
Net movement and direction of porpoise recaptured in Sets 9 and 11.

○ Set number

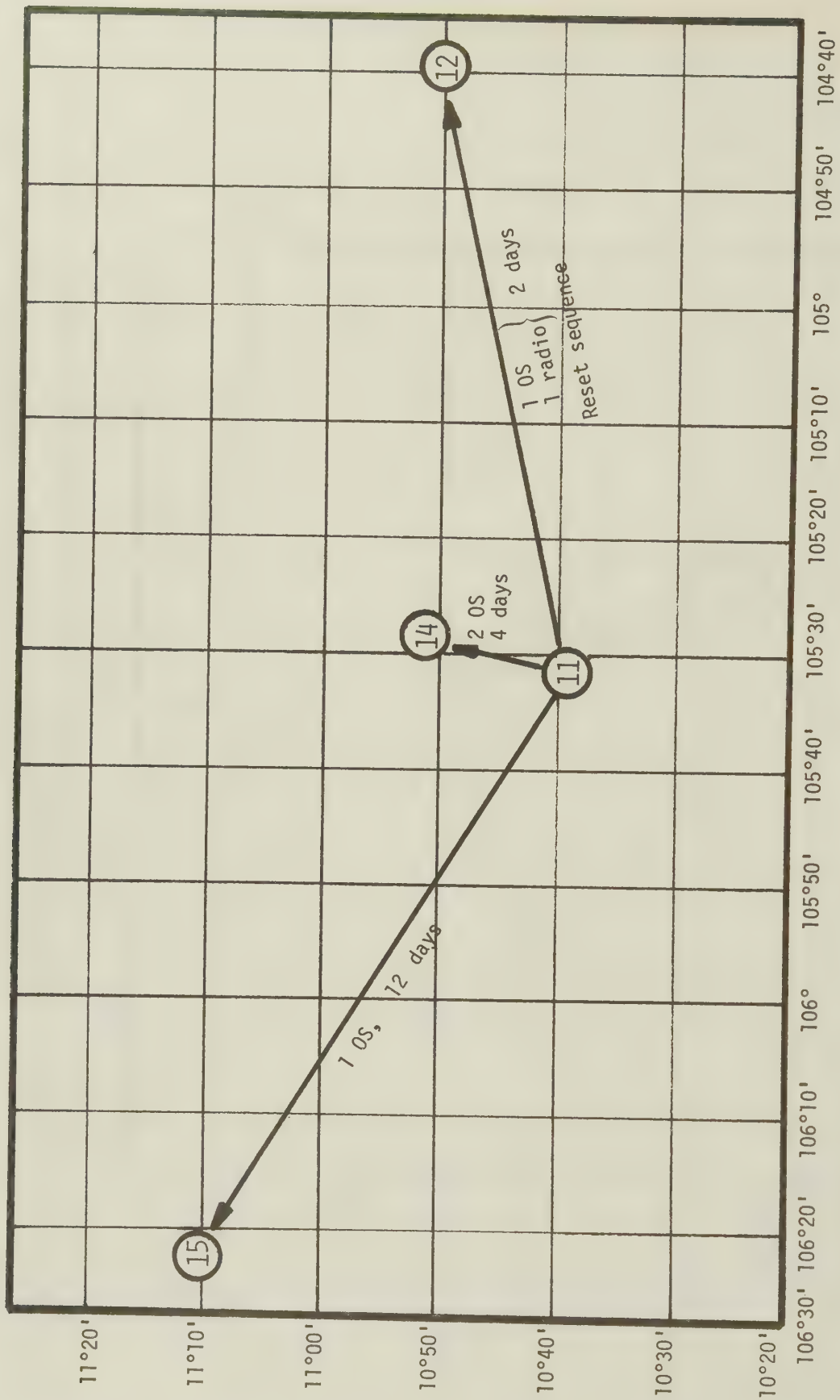
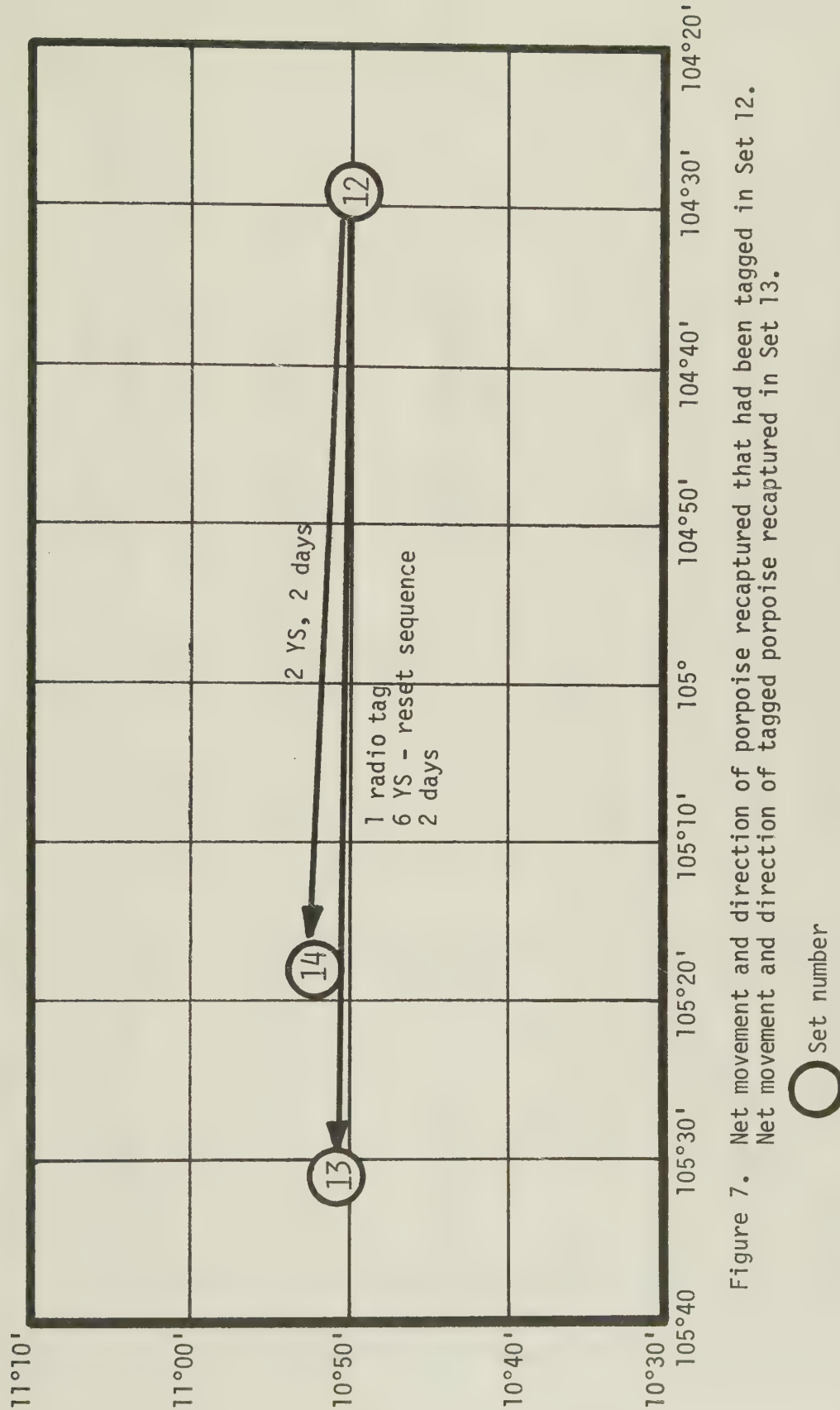
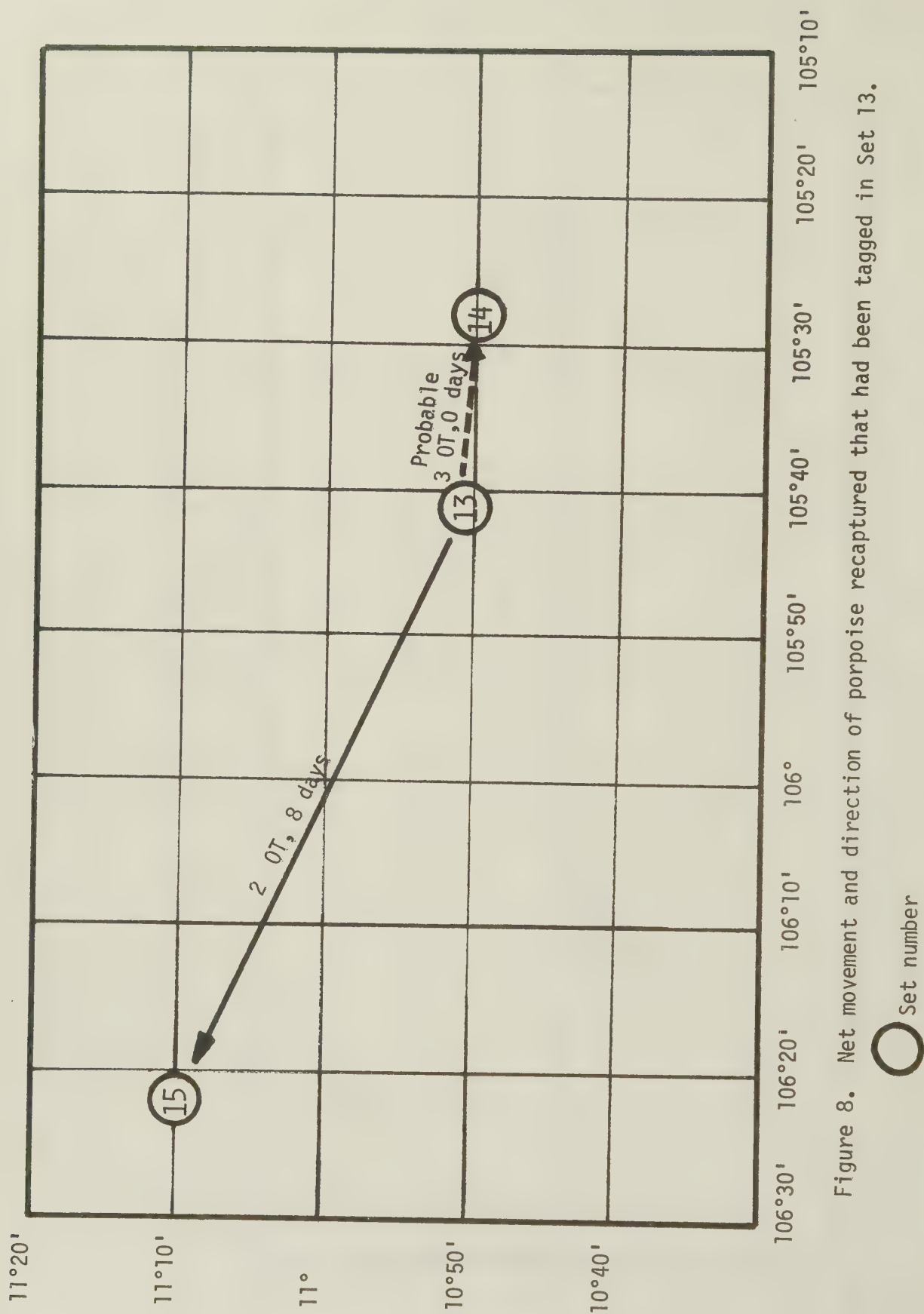


Figure 6. Net movement and direction of porpoise recaptured that had been tagged in Set 11.
 Net movement and direction of tagged porpoise recaptured in Set 12.

○ Set number





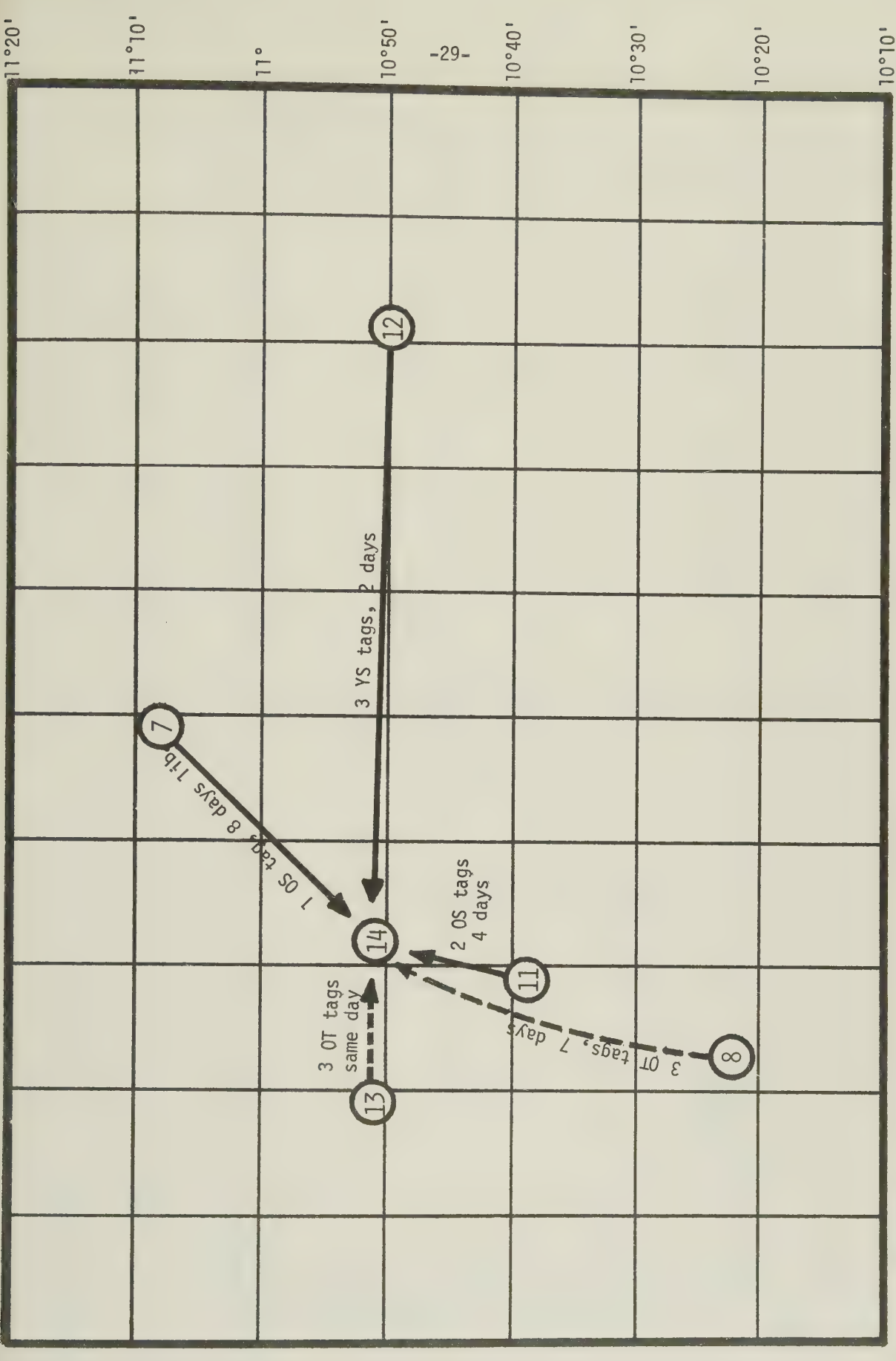


Figure 9. Net movement and direction of tagged porpoise recaptured in Set 14.

○ Set number

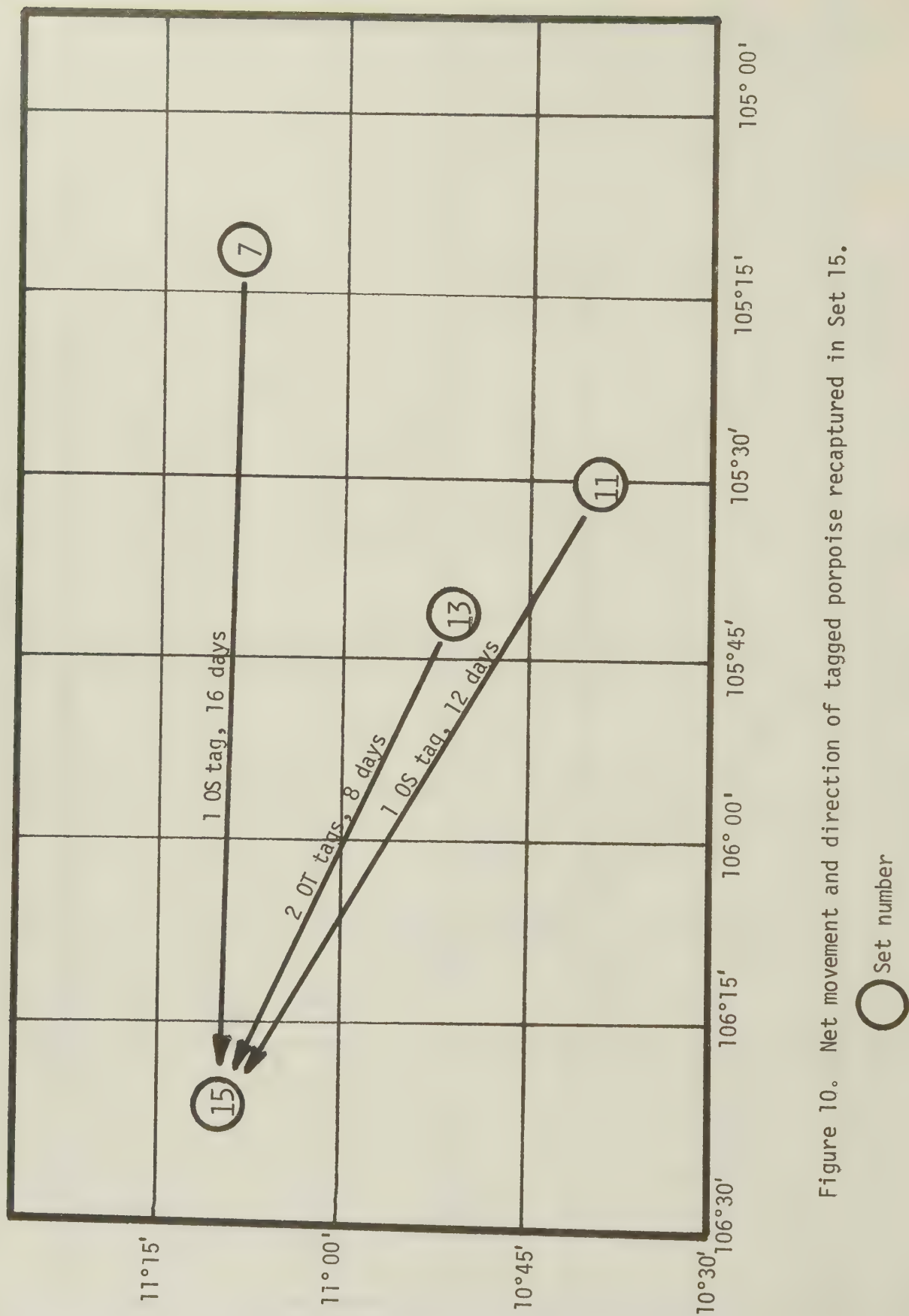


Figure 10. Net movement and direction of tagged porpoise recaptured in Set 15.

Table 12. Summary of reset and recapture data in the PSIS. Sets 11, 12, and 13 comprised the planned reset sequence (radio tags were placed in Sets 11 and 12 to follow the school). Sets 7, 8, and 15 occurred in the same geographical area as the reset sequence. Recaptures from these sets indicate that they may be included in reset analysis (see text). Note that tagged animals were seen in Sets 9 and 14, but since there was no systematic examination or count because the PSIS was not used, they are not included in this summary.

Set No.	Time in days from Set 7	No. of tags released in set 1/	No. examined for tags in set 2/	No. examined and not released, i.e., killed in set	Number of tags recaptured 3/ when the marks were placed in:					Ratio of recaptured to number examined
					Set 7	Set 8	Set 11	Set 12	Set 13	
7	0	131	149	13	-	-	-	-	-	-
8	1	131	165	5	0	-	-	-	-	0.0000
11	4	104	124	8	0	1	-	-	-	0.0081
12	6	43	49	4	0	0	2	-	-	0.0408
13	8	56	75	1	0	0	0	7	-	0.0933
15	16	66	101	4	1	0	1	0	2	0.0396

1/ Includes all releases: radio-tags, disc tags placed, and disc tags recaptured and released.

2/ Includes animals: killed, tagged, examined but not tagged, and escaped and counted.

3/ Includes examined disc and radio-tagged animals and escaped (but counted) disc-tagged animals.

The ratio of recaptured tags to the total number of animals examined during a set ranged from 0 to 9 percent. The high value of 9 percent occurred for a reset in which a substantial number of tagged animals were released together. Even so, if the schools were highly cohesive, it is expected that this percentage would have been larger. Either natural movement between schools or the disruptive nature of the tagging process served to mix the animals in the finite area covered by Sets 7 through 15. This is shown by the number of sets represented by the recaptured tags. A more mixed population indicates that the complicated statistical designs which incorporate cluster analysis to estimate density from mark-recapture data may be avoided. The drawback is that more tags will likely be required for equivalent statistical accuracy.

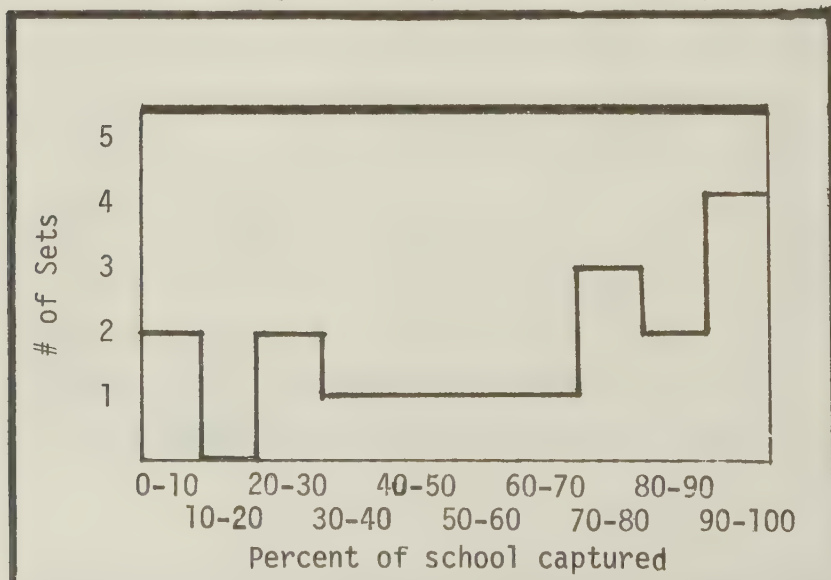
4. Porpoise aging studies

Tetracycline was injected into 331 porpoise, and orange "T" disc tags were placed on all of these animals. Three animals with orange "T" tags were recaptured and examined through the PSIS. None of them displayed any obvious stress or physical trauma; therefore, they were released with the tags intact. Two of these animals had carried the tags for eight days.

5. Observations of the evasive behavior of porpoise and the behavior of porpoise within the PSIS

During the course of the trip, chase was initiated on a total of 25 porpoise schools, resulting in 17 sets and eight aborted chases. In two sets (14 and 17), all animals present at the beginning of the chase were captured. On another two sets (5 and 18), all porpoise evaded capture. Some porpoise evaded capture on the remaining 13 sets. The percent of porpoise schools captured in all sets is plotted in Figure 11.

Figure 11. Frequency of partial school captures



Schools chased and subsequently set upon were estimated to range in size from 78 to 2664 animals, and averaged 641. The number of porpoise estimated to be captured per school ranged from 0 to 1110, and averaged 336; thus, it is estimated that about 50 percent of the animals chased were captured.

a. Evasive behavior during the chase

During the chase, the porpoise schools responded to the speedboats either by fragmenting (i.e., animals were observed traveling in different directions), bunching up (i.e., the animals formed a tight, closely grouped school), or not running from the speedboats but instead with the vessel and speedboats, surfing the wake or the bow waves. If the speedboats applied excessive pressure, i.e., crowded the animals too quickly, the porpoise broke up into small units of animals which eluded the speedboats by diving under them or which escaped out the bow end of the encircling vessel.

As the speedboats chased the animals, the spotted porpoise ran low to the water exposing only a small portion of their backs and dorsal fins when surfacing for air. The spinner porpoise leaped out of the water when they surfaced for air. This made the spotted porpoise less visible than the spinner porpoise during chase.

b. Evasive Behavior on Aborted Chases

There were a total of eight aborted chases: i.e., speedboats were deployed and porpoise chased, but the net was not set (Table 13). Three of the chases involved schools which were scattered over an area estimated at one or two square miles and which could not be bunched properly for a set. The other five schools chased did not meet the specifications for a PSIS set. There was not a large enough school or the proportion of spinners was too high; thus, the chase was terminated.

c. Evasive Behavior after Net was Set

Once the net was set, the porpoise's reactions varied. Some porpoise escaped between the skiff and the seiner as they approached the skiff. Others dove under the net by the stern of the skiff or half-net marker. Still others escaped through the opening between the stern of the seiner and the stern end of the net as the towline was retrieved.

Table 13. Summary of data of porpoise chased but not set on.

Date	Chase	North Latitude	West Longitude	Duration of Chase (min)	Spotters	Eastern Spinners	Total	Comments
10/3/78	1	16°32'	100°16'	48	250	0	250	School could not be bunched up
10/5/78	2	15°26'	100°54'	35	720	80	800	Radio-tracked school could not be bunched up
10/6/78	3	12°40'	103°43'	6	19	3	22	Small school
10/7/78	4	11°18'	104°43'	9	7	170	177	High percent spinners
10/8/78	5	10°42'	105°24'	5	63	187	250	High percent spinners
10/9/78	6	10°14'	106°24'	15	275	1308	1583	High percent spinners
10/10/78	7	10°38'	106°27'	14	0	1066	1066	High percent spinners
10/21/78	8	09°00'	105°16'	4	75	5	80	Scattered school

d. Behavior within the PSIS

After the porpoise were transferred from the net into the PSIS, they grouped together very tightly in the corral. In general, they remained in the center of the corral, although they also moved as a group from one end to the other. The spotted porpoise usually rafted, circled, and vertically displaced one another within the group. The spinners never rafted but constantly swam and dove. Their swimming motions were abrupt and quick, making it difficult for the tenders to avoid being struck.

Both spotted and spinner porpoise exhibited the characteristic "sleeper" behavior on the bottom of the corral; as the corral became less crowded, the tendency for this behavior decreased. Adult animals were more frequently observed as "sleeping," whereas the juveniles usually remained active. Some spotted and spinner porpoise were observed charging the corral webbing in Sets 11 and 12. After animals had been tagged and returned to the corral for release as a group, the untagged animals remaining in the corral became increasingly difficult to capture. It was difficult to sort out and find the untagged animals. As the number of animals in the corral decreased, their activity increased.

Transferring the animals from the waiting pen to the chutes involved moving the animals by hand. Spotters and spinners exhibited a variety of reactions to this transfer. Some animals of both species reacted violently when handled, while others remained calm. When the animals were in the chute, some would stiffen their bodies and slap their flukes, while others thrashed about and had to be restrained. Vocalizations were heard continuously in the water and vocalizations could be heard quite clearly when the animal was high and dry in the chute. When the dorsal fins on the animals in the chute were being cored and notched, the reactions varied from sideways head movements to fluke thrashing and vocalizations. There were no significant reactions observed from the tetracycline injections.

When spotted and spinner porpoise were released from the PSIS after processing, some dove down and resurfaced about 50 feet away. Subsequently, some animals were observed swimming rapidly and others slowly. A small number of animals remained in the vicinity of the PSIS after being released, although the majority left the immediate area.

6. Research on porpoise disease factors

Thirty-eight of the 45 animals incidentally killed were completely necropsied. The other seven were either unrecovered or ruined for examination by shark bites. Samples from most organs, parts of the muscle, and, in some instances, sections of brain were collected for the pathology research. The results will be presented in a contract report to NMFS by Mr. William Walker and Dr. Dan Cowan.

7. Capture-myopathy studies

Blood was collected from 15 spotted porpoise during Set 15 and from 19 spotted porpoise during Set 16. The times at which the samples were obtained were noted, so that the state of the animals can be related to the duration of the capture-examination process and events occurring within that process. Tissue samples from the major organ systems were collected from one spotted and three spinner porpoise.

8. Comparative feeding habits

Five or more porpoise were killed during three PSIS sets. The tuna were brailed aboard the seiner during the period when all hands were occupied with tagging or examining porpoise in the PSIS; thus, no tuna were flagged. Stomachs from five spotters and one spinner were collected.

9. Biological sampling

The standard NMFS life history data was collected on 19 spotted porpoise, 16 spinner porpoise, and 2 common dolphin (Delphinus delphis). Eyes were collected from 8 spotted and 9 spinner porpoise. Melon samples were collected from 3 spotted porpoise, 2 spinner porpoise, and 2 common dolphins.

B. Ancillary Research

1. Research to reduce porpoise mortality

a. Observations of the backdown channel

The formation and underwater configuration of the backdown channel was observed from rafts during Sets 3, 6, 9, and 17. Some degree of "stern sway" was always noted. In Set 17, a set on Delphinus delphis, stern sway contributed to mortality. Two Delphinus, moving away from the apex of the backdown channel, swam into the fold created by the webbing on the stern side of the channel. Rescuers were unable to rescue them.

b. Observations of malfunctions

There were no roll-ups and no bunchline fouling during the cruise. In Set 14, net webbing became entangled around the starboard propeller and propeller shaft when the starboard engine was accidentally engaged. Underwater photographs of the entanglement were taken but were underexposed. The accident occurred at 1627, two minutes before "rings up." The first attempt to roll net aboard failed. At that time, it became obvious that the net entanglement on the propeller was serious, a diver would be required to cut the webbing free, and there would be a substantial time delay. Two speedboats and the PSIS support boat towed on the net to prevent collapse. The towing points were at 1/4, 1/2, and 3/4 net. The diver was able to cut enough webbing free so the net could be rolled aboard. The total delay in net rolling was 36 minutes. A fourth speedboat then joined the others in towing while the net was being rolled.

During the entire incident the net skiff maintained a steady pull abaft of the starboard beam. Sufficient surface area and net volume was maintained through these efforts for the estimated 1100 porpoise that were in the seine. None died.

c. Herding stimuli

In Set 6, one underwater white light flare was tested for its effect on the behavior of tuna or porpoise. The flare was lowered from a raft on a 10-foot piece of twine near 20-30 rafting spotters. There was no avoidance by the porpoise other than the normal mild avoidance to the raft. There were no tuna in the vicinity during the test.

d. Net measurements

The distance from the port rail of the vessel to the corkline was measured with a Lietz rangefinder during seven sets (Table 14). An analysis of this data is not presented in this report.

2. Standard cruise data

A marine mammal watch was maintained daily by the scientific party and ship's crew; 188 hours of sighting effort resulted in 51 porpoise school sightings and 29 sightings of other marine mammals. The standard NMFS set log was kept for each set, and a record of the vessel's activities was kept for each of the 50 days at sea.

Table 14. Net measurements (distance in meters) from port rail amidship to 1/4 net, 1/2 net and backdown apex (BD apex) at specified times during the set.

Set #	Ortza In			One-half Pursued			Rings Up			Roll Net			Start Backdown		End Backdown	
	1/4 net	1/2 net	BD Apex	1/4 net	1/2 net	BD Apex	1/4 net	1/2 net	BD Apex	1/4 net	1/2 net	BD Apex	BD Apex	BD Apex	BD Apex	BD Apex
003	180	-	140	-	-	-	120	72	78	72	130	93	110		125	
005	140	180	185	-	-	-	88	66	99	90	96	80	-		-	
006	220	-	240	-	-	-	89	84	-	91	86	84	100		120	
014	-	-	270	-	-	270	-	97	77	84	93	79	100		125	
017	210	-	240	-	-	-	98	66	-	-	-	-	-		-	
018	175	-	185	-	-	-	81	64	85	86	91	86	65		130	
018	99	-	170	-	-	-	85	63	88	85	80	83	-		-	
Ranges and averages (number of measurements in parenthesis)																
Low	99	180	140	-	-	270	81	63	77	72	80	79	65		120	
Hfgh	220	180	270	-	-	270	120	97	99	91	130	93	110		130	
Average	171	180	204	-	-	270	94	73	85	85	96	84	94		125	
	(6)	(1)	(7)			(1)	(6)	(7)	(5)	(6)	(6)	(6)	(4)		(4)	

3. Environmental data

XBT traces were collected 53 times during the 50 days at sea. The XBT data as well as the local weather data were transmitted to WWD when possible.

VI. PORPOISE MORTALITY

Thirty-six porpoise died in the nine PSIS sets: 21 within the PSIS, 14 in the purse seine, and one in the interface between the corral and seine. The causes of death are listed in Table 15. The number of porpoise captured in the PSIS sets was estimated at 1428. The mortality rate (expressed as a percentage of those captured), was about 2.5 percent. The kill per set was 4.0.

Nine porpoise died in the six gear sets that captured porpoise; the causes of death are listed in Table 16. The number of porpoise captured during the gear sets was estimated at 4335. The mortality rate expressed as a percentage of those captured was about 0.2 percent. The kill per set that captured porpoise was 2.66.

VII. DISCUSSION AND CONCLUSIONS

The results of Cruise IV provided extremely valuable information with regard to the objectives of the cruise. The tagging work defined the operational limits of tagging: the number of marked animals which one can expect to be released during a cruise. Additionally, areas of improvement in the tagging rate and expected magnitude of that improvement were defined. From these data future tagging work can be planned more effectively.

Feasibility of a tagging program depends upon the number of tagged animals which can be released and the number which can be subsequently recaptured. The first aspect is governed largely by economic and technological considerations; the second by the number, movement, density and variability of the animals themselves. The results of the tagging portion of Cruise IV have helped to define the limits of both.

The greatest number of tags placed during a single set was 131. Personnel could probably tag 150 animals consistently in tagging sets using the present tagging apparatus, barring other research objectives such as blood sampling or tetracycline injections. However, because of the limited capacity of the PSIS corral, an average of 100-120 animals tagged would be a more realistic estimate.

Weather conditions limited the amount of tagging done on this cruise. The vessel spent 40 days on the fishing grounds. The PSIS could have been deployed on 25 of those days because the weather was rated at Beaufort 3 or less; however, three of those days were spent radio-tracking porpoise, so the actual number of days available for PSIS operations was 22. Nine PSIS sets were made, so PSIS sets were made on 41 percent of the days

Table 15. Causes of porpoise death during PSIS sets

<u>Death within Purse Seine</u>		
<u>Cause</u>	<u>Number</u>	<u>Comments</u>
Canopies	13	11 spotted, 2 spinners 12 porpoise died on one set when large canopy formed under the PSIS
Entangled in 1-1/4" mesh	1	Spinner
TOTAL	14	
<u>Death within PSIS</u>		
Entanglement in 1-1/4" mesh	3	Two spinners, one spotted
Banging head on net	3	Spinners
Caught between seine and corral	1	Spinner
Entangled below crowder	1	Spotted
Injury in corral	1	Spotted
Unknown	12	Six spinners and six spotted Two of each species were neonates
TOTAL	21	

Table 16. Causes of porpoise death during gear sets

Cause	Number	Comments
Entanglement in 1-1/4" mesh	2	Spinners
Entanglement between cork and lacing	1	Spinner near apex
Folds and canopies	3	Common dolphin
Unknown	3	1 spotted/2 spinners
TOTAL	9	

possible. The weather was rated over Beaufort 3 on 15 days. The weather on three of those days had started at about Beaufort 2 but rapidly deteriorated after sunup.

Depending upon the time of year in which a tagging cruise was fielded, at least ten tagging sets could be expected in 40 days. Coupling this with the tagging rate, a conservative estimate of the number of animals which could be tagged during a 50-day cruise is 1000 (with the present technology). This could be substantially increased by fortuitous circumstances of encounters with schools and good weather, which are factors beyond the control of the experimental design. The tagging time might be decreased to as little as two minutes per animal with small changes such as: shorter bolts, faster coring tools, a pre-assembled tag-bolt-washer apparatus, and two more people to deliver animals to the tagging chutes. Additionally, increasing the volume of the PSIS corral would allow more animals to be tagged per set. However, this might require more people tending the animals to maintain their safety.

The tagging-reset study indicates that the process of tagging acts to essentially randomize the marked sample within the population. Any estimates of migration rates among schools will have to be tempered by the small number of resets and recaptures. However, the data will be useful in further experimental design. Perhaps as useful in a design will be the recapture data not associated with the reset sequence. These data will allow an "order of magnitude" density estimate which will be useful in planning large-scale tagging. Additionally, the plotted movements of the tracked animals shed light on the speed with which the animals move and their behavior under tracking conditions. Also, the relative ease with which pelagic porpoise can be radio-tracked was shown again.

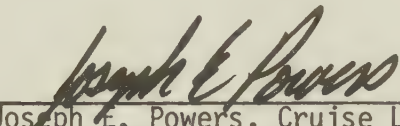
All three of the animals radio-tracked for a significant amount of time (Sets 4, 11, and 12) moved a considerable distance (Figures 2 and 3). During the successful reset sequence, the animal radio-tagged during the first reset (Set 12) passed very close to the location of the original set (Set 11). Thus, the reset sequence took the form of a nearly closed circuit. Since the same animal was not continuously tracked over the entire reset sequence and no tagged animals from the initial set occurred in the second reset, no conclusions may now be drawn regarding the patterns of movement. Also, there does not appear to be a consistent difference between night and day movement.

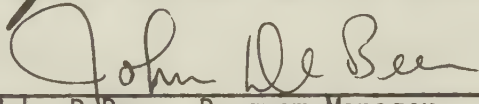
The school structure data provided from this cruise and from Cruise II in the form of length, color-phase, and sex distributions are essentially the only samples of live animals of these species available for these particular variables. It is recognized that the sampling by capture in the purse seine and examination in the PSIS may be biased in respect to

the sex and age distribution actually occurring in the population. However, it is likely that any such bias that exists is less than that which occurs in the sample of incidentally killed animals, which is what was previously available. Comparisons of the distributions of the live animals with the dead animals from the cruise and with NMFS observer samples from appropriate time and area strata will help to assess assumptions of cross-sectional kill rates, natural mortality rates, and reproductive rates in the population dynamics models.

The data generated from Cruise IV of the Dedicated Vessel served to evaluate questions of scientific and technological research relative to stock assessment and mortality reduction. The results of the cruise also allowed formulation of further research problems which could not have been addressed prior to the Dedicated Vessel Program.

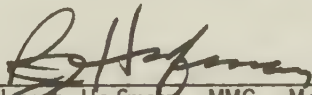
VIII. SUBMITTAL:

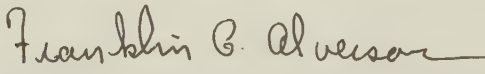

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APPENDIX A - Tagging Methods and Tetracycline Injections

-Tagging

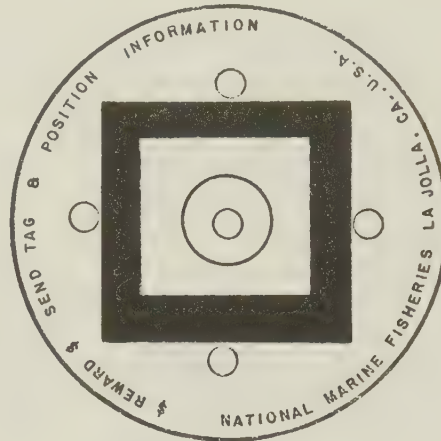
The tags were 2½-inch diameter discs made of polyurethane 2103 76DX in either international orange or international yellow. They were designed to be convex in nature such that they would cup to the surface of the dorsal fin when in place. The attachment equipment consisted of an 1808 stainless steel bolt and washer, self-locking nylon-lined nuts, and a virgin Teflon sleeve. The sleeve was biocompatible (would not cause a reaction) and was large enough to allow the bolt to rotate inside. The disc tags (Figure A-1) were embossed with a unique number, a geometric design, and a legend explaining what to do with tag recoveries. The orange "T" tags were used exclusively for tetracycline injected animals. For these the legend was printed in both English and Spanish stating that a \$100 award would be given to anyone who returned the tag, the head of the porpoise which had the tag, and the date and geographical position at which the animal was incidentally killed. The disc tags with square and circular geometric designs had the legend offering a \$5 award for the return of the tag and the date and position at which it was recovered.

In preparation for tagging animals, the tags were strung on nylon cord and attached to the working chutes. Additionally, buckets were fastened to the chutes to hold the miscellaneous equipment and tools. The Teflon sleeves were kept in a bottle of surgical antiseptic solution until tagging began, at which time they were kept in pouches and pockets of the people working in the chutes.

The actual process of tagging occurred in the following sequence. The animal was brought into the working chute where it was measured and sexed by the two people in the chute; one person then removed a pair of disc tags from the nylon cord, read the number from the tag, and called the number, the sex, the color phase and the length to the recorder in the support boat. A ¼-inch hole was then cored in the dorsal fin with a stainless-steel coring tool. (This tool was based on a flywheel principle and had stabilizing attachments which helped to assure that the hole was perpendicular to the fin.) As the coring bit was retracted from the fin, a teflon sleeve (precut to the approximate width of the fin) was inserted into the hole. (The sleeve was slightly larger than the hole and acted as a compress to stop the bleeding.)

Next, the assembly of tag, bolt, and washer was inserted into the sleeve, and the other tag and nut was fastened to the other side. A nut driver was then used to hold the bolt end while a socket wrench was used to tighten the nut. The nylon lining of the nut prevented it from backing off of the bolt. When the nut was right enough, the excess bolt was severed with bolt cutters. If tetracycline injections were administered, they were administered at this point. Finally, notches were clipped, according to a predetermined notch code, along the posterior edge of the dorsal fin using an adjustable notching tool, and the animal was released.

TAGS USED IN RESET SEQUENCE



Orange and Yellow

TETRACYCLINE TAGS

English Side



Orange Only

Spanish Side



Orange Only

Figure A-1

-Tetracycline Injections

Each tetracycline-injection apparatus consisted of the following:

1. A back-pack, lined with foam from which two circular sections had been removed, forming two recessions to carry bottles of tetracycline;
2. A continuous-pipetting outfit utilizing hypodermic needles, a glass syringe, and a 2-meter length of tubing with which to draw liquid from the bottles; needles were of two gauges, 18 ga., 2-3/4" (used with 5 cc. syringes), and 15 ga., 2-3/4" (used with 10 cc. syringes). The tubing was Tygon(R) (3/8" OD x 1/4" ID x 1/16" thick); the tubing was secured to each bottle to prevent air bubbles from being drawn into the tube;
3. A "holster" constructed of PVC pipe and secured with a Velcro ring to a nylon belt worn by the researcher; the base of the "holster" was secured to the researcher's thigh with a twine lanyard.

Since two people were performing this procedure, some of the operations were normally done simultaneously. However, if the animal reacted to handling by flopping in the chute, both people would be required to restrain it while that phase of the tagging process was completed.

APPENDIX B - Radio tracking equipment

Complete VHF (148 Mhz) and HF (27 Mhz) systems were used for radio tracking. The primary VHF system was based on Telonics MK-IV transmitters and an Ocean Applied Research OAR ADFS 320 automatic direction-finder which was modified to receive a 30 ms pulse length. The VHF transmitters provided a continuous 30 millisecond pulse at 0.6 second intervals. The packs were hermetically sealed and had life expectancies of 2-1/2 months. The antenna was a 1/4-wavelength whip. The selected frequencies were 148.748, 148.750, 148.798, 148.800, 148.848, and 48.850 Mhz. The transmitters were packaged as a single cube measuring 2-1/4" x 1-1/2" x 1-1/4," and each weighed 189 grams.

The ship's adcock antenna, an OAR model AA 380 400, which was mounted 8 feet above the roof of the crow's-nest, was used with the OAR 320 ADFS. The antenna's cables terminated in the pilot house where the ADFS was located. The cables were connected to a preamplifier with the output running to the ADFS providing 10 Db of gain. Interfaced with the ADFS 320 was a Rustrak strip chart recorder for recording the surfacing times of the tracked animals; however, it proved too insensitive to be functional.

A secondary VHF system consisted of the Telonics TR-2 receiver, an omnidirectional whip antenna, and a three-element quad antenna. The antennas were also mounted on top of the crow's-nest. The audio output of the TR-2 could be connected to a cassette recorder to obtain surfacing frequencies.

The HF system was based on OAR AB-245 transmitters with frequencies of 27.585 and 27.595 Mhz. The transmitter consisted of two tubes joined in the front, measured 5-1/2" x 3/4," and weighed 237 grams. The antenna was a 1/4 length top-loaded whip. These beacons were switched off by a saltwater switch when submerged. The receiver was an OAR 210 with a beat frequency oscillator, and there was an extra OAR 210 as a back-up. The primary antenna was an OAR adcock Model AA-270-400, and there were back-up antennas, cables, etc., for this system as well.

Plastic saddles were designed and constructed for this study. The saddles were lined with closed-cell foam to avoid abrasion of the fin and back. The OAR beacons were attached directly to the saddles with plastic electrical ties. The Telonics transmitters were attached to one side of the saddle and a counterweight attached to the opposite side. The whole saddle was potted over to make a more hydrodynamically acceptable package. The packs were attached to the dorsal fin using a spring-loaded bolt with a corrosible nut.

A VHF range test was conducted October 21. The transmitter was left adrift with a radar reflector on a weighted pole. The test was conducted as the vessel left the beacon. Since the target was directly aft, it was lost on radar at about two miles. The VHF antennas used were the highest on the vessel so they were not affected. Maximum range for the OAR ADF 320's system determined by dead reckoning was between 9.0 and 9.5 nautical miles. The Telonics system had a range of 14.4-15.0 nautical miles.

